Endocrine Function in Aquatic Invertebrates and Evidence for Disruption by Environmental Pollutants

In previous research programmes, the Environment Agency has identified fish and marine molluscs to be at risk of adverse effects from endocrine disrupting substances. Concerns about other animal groups in similar environments led to a review of the potential risks from exposure to such substances. From this review, the Agency would be able to determine its policy position and identify further work necessary so as to achieve its statutory duty to protect the environment from pollution.

The objectives of this study were to: (1) summarize the key elements of invertebrate endocrine systems: (2) assess whether existing test systems are adequate for the detection of endocrine disruption in invertebrates, what new tests might be required, and what end-points should be measured: (3) review the published evidence for endocrine disruption in aquatic invertebrates: (4) summarize the relevant UK and European legislation impacting on the monitoring and management of freshwater ecosystems: (5) highlight gaps in knowledge and recommend research priorities.

It is clear that utilisation of hormones to control and coordinate biochemical, physiological and behavioural processes is common to all major invertebrate taxa. Neuropeptide and non-peptide endocrine messenger systems have been characterised in invertebrates. Both of these systems are potentially "at risk" from interference by disruptive contaminants. Among the aquatic invertebrate taxa the endocrine systems of the two major arthropod classes, insects and crustaceans, are best documented. In both classes vertebrate-type steroids are detected but their functional significance is yet to be confirmed. The presence of vertebrate-type steroids has been reported for a number of molluscan species and in some cases the evidence that these steroids play a functional role is strong.

Evidence for a significant role of vertebrate-type steroids is strongest within the echinoderms, where they may have a role in the control of growth and reproduction. For the remaining groups considered within the review (the Coelenterata, Porifera, Acoelomata, Aschelminthes and Annelida) there are varying degrees of understanding of endocrine-type processes and isolated reports of steroid synthesising activity.

A range of compounds with known endocrine-disrupting activity in invertebrates have been deliberately introduced into the environment and these frequently have been shown to have impacts on non-target species at low concentrations. These include the insecticides tebufenozide, methoprene, DDT and its derivatives, and endosulfan; the herbicides atrazine, diquat and MCPA; and the biocide tributyltin (TBT). TBT is the best-known endocrine disrupter in invertebrates, having been identified as the agent responsible for global declines in populations of several molluscan species, through interference with reproduction. The most commonly described effect of TBT exposure, termed imposex, is the imposition of male reproductive organs on the female neogastropods resulting in infertility. Some metals, notably cadmium, and PCBs are also suspected to be invertebrate endocrine disruptors.

Conclusions

A key conclusion is that all invertebrate groups must be considered 'at risk' or potentially susceptible to interference at a sub-lethal level by chemicals in the aquatic environment. It is probable that effects of disruption will encompass reproduction, moulting, feeding, and behaviour. However, caution should be employed when ascribing adverse effects of

contaminant exposure to disruption of endocrine processes. Relatively few cases of contaminant effects on vertebrate reproductive processes can be confidently ascribed to endocrine disruption. This concern is exacerbated in the case of invertebrates where endocrine processes are less well understood than is for many vertebrate species.

The project recommends that:

- basic research should be directed to testing with existing laboratory ecotoxicological protocols that include response measures (such as reproduction) likely to detect effects of endocrine disruption, in addition to other modes of toxicity. The work should aim to identify the endocrine disrupting mechanisms underlying the effects seen, thereby developing definitive evidence for which chemicals are invertebrate endocrine disruptors.

- the key environmental research need is to establish the evidence for endocrine disruption in individuals or populations. For this, systematic field biological monitoring is needed in situations where chemicals with endocrine disrupting capability are most likely to be found, e.g. downstream of sewage or industrial effluents in rivers and in the marine environment. "Sentinel" organisms together with appropriate end-points/indicators of endocrine-disrupting activity, should be identified in Annelida, Mollusca, and Arthropoda (crustacea, and insecta).

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